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POLYMORPHISM AND INHERITANCE OF GLIADIN PROTEINS IN WHEAT LANDRACES OF UZBEKISTAN

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SUMMARY

Wheat genotypes grown in Uzbekistan and other Central Asian countries cannot compete with commercial cultivars for productivity. These landraces are valuable genetic resources that could benefit in developing new cultivars enriched with nutritious microelements and other ingredients beneficial for human health. As a result of wheat research, for the first time, preserving the 31 landraces in their natural form in the remote territories of Uzbekistan ensued, including a catalog of compilation by determining their economic and morphologically valuable features. Based on cluster analysis and quantitative characteristics, local wheat genotypes attained five groupings with a compiled dendrogram. With the dendrogram, determining the morphological attributes of ancient local cultivars of wheat materialized, even though the grain color is the same, a sharp difference is noticeable, but still similar based on quantitative characteristics that ensure the grain yield. In ancient local wheat cultivars, plant height and 1000-seed weight have a weak correlation with other traits, and a strong positive association was distinct between the spike length and spikelets per spike and the number and grain weight per spike. The polymorphism of soft wheat landraces showed according to the electrophoretic spectra in the grain's gliadin proteins. The electrophoretic parameters of gliadin proteins indicated that of the six samples of cultivar Kzyl-bugdoy listed in the catalog, only four have similar electrophoretic spectra. In cultivar Ak-bugdoy's four specimens, three have identical spectra, while three from the cultivar Surkhak have different bands. Based on individual selection and according to electrophoretic spectra from wheat landraces, the release of the wheat cultivar Kairaktash was due to its high baking and nutritional value.

Keywords: wheat (*Triticum aestivum* L.), mountainous Uzbekistan, landraces, morphological analysis, quantitative characteristics, gluten content, electrophoretic analysis, gliadins

Key findings: The presented study sought to identify the potential soft wheat landraces based on quantitative traits and electrophoretic spectra of gliadin proteins in Uzbekistan. Adapted to the rainfed conditions of the Republic, the developed cultivar Kairaktash ensued through individual plant selection from ancient local wheat populations.

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INTRODUCTION

Common soft wheat (*Triticum aestivum* L.) is one of the most widely grown cereals occupying the largest area in the world and is one of the staple foods consumed by humankind. More than half of the world's people use wheat as a staple. It is imperative to conduct intensive breeding to enhance the grain yield and quality of cereals, including soft wheat, to ensure the food security of the growing population.

Modern wheat cultivars are often genetically similar and have a relatively narrow genetic base. Therefore, it is necessary to use genetic sources with greater diversity in breeding. Landraces that have evolved from a combination of natural selection and breeding to meet farmers' needs tend to have a broader genetic base, thus, can provide valuable traits for breeding (Belay *et al.,* 1995; Tesemma *et al.,* 1998). Such wheat genotypes have characters tolerant to local stress factors and a stable yield (Li *et al.,* 1997). Old-time cultivars reckon as essential genetic resources of the gene pool because they represent a wide range of intraspecific genetic diversity which can benefit in developing new cultivars with better genetic potential (Zou and Yang, 1995). Legacy cultivars provide much variety in protein content and other grain qualities compared with modern cultivars (Rodriguez-Quijano *et al.,* 1994).

Massive research follows through on the conservation and rational use of plant genetic resources, which is the basis for developing breeding, sustainable agriculture, and food security worldwide. Wheat landraces that have emerged from a combination of natural selection, evolution, and breeding for productivity are descriptive of tolerance to local stress factors, stable yields, and grain qualities compared with existing commercial cultivars. Therefore, the plant genetic resources represent a valuable part of the gene pool and require involvement in breeding for developing early maturing, high-yielding, and stress-tolerant cultivars.

Evaluation and selection of breeding material based on protein markers make it possible to conduct nomination quickly and efficiently and to manage the inheritance of desired parameters from parental genotypes to hybrid populations. The most widely studied wheat proteins are the storage proteins gliadins and glutenins. The complete characterization of individual fractions and components of proteins appeared in several past studies (Newton *et al.,* 2010; Jaradat*,* 2012). Hence, studying the genetic patterns of protein accumulation in the grain of various wheat cultivars and the use of wheat genotypes as markers of gliadin protein components in identifying potential wheat genotypes is a present dire need (Shewry *et al*., 1995; Johansson *et al*., 2001).

Research steered on the conservation and use of the genetic diversity of wheat to introduce them, as well as to introduce the ancient landraces in modern breeding processes and to improve the existing commercial wheat cultivars (Khramtsova and Kiseleva*,* 2005; Park *et al.,* 2012; Stepochkin, 2012; Moore*,* 2015). In Uzbekistan and Central Asia, studies have also focused on the collection, biodiversity, and identification of ancient local cultivars of wheat (Baboev *et al.,* 2013, 2017, 2021; Khamroev, 2019; Amanov *et al.,* 2020, 2022; Buronov and Xamroev, 2022; Qulmamatova, 2022), with research also carried out in the Commonwealth of Independent States (CIS) (Muminjanov *et al.*, 2021). In all these studies, analysis of the ancient local cultivars of wheat delved into the distribution area, economically valuable traits, and composition of microelements in wheat grains.

Several studies have proceeded on the use of wheat grain's stored proteins as genetic markers and a catalog of jointly inherited blocks of protein components of gliadin came about in soft and durum wheat (Sozinov and

Poperelya, 1979; Sozinov, 1985; Metakovsky *et al*., 1997; Kazakov and Karpilenko, 2005; Kudryavtsev, 2007; Dragovich, 2008; Melnikova, 2010; McIntosh *et al*., 2015). However, genotyping, complete identification with biochemical markers, genetic variability, the heritability of the quantitative traits, and electrophoretic analysis of the storage proteins in ancient local wheat cultivars grains have limited studies.

The relevant study assessed the local and ancient wheat landraces of Uzbekistan for genetic diversity based on the quantitative features (morphological and yield-related), traits association, comparative analysis of the electrophoretic spectra, and inheritance of gliadin proteins, the variability and heritability of polymorphism, the economically valuable characters, and gliadin proteins in F_1 and F_2 populations.

MATERIALS AND METHODS

The presented study comprised the genetic material (wheat cultivars collected from the mountainous and foothill zones of Surkhandarya, Kashkadarya, and Jizzakh regions, Uzbekistan), environmental conditions, scientific methodologies, and the research data used during 2010–2019 at the Durmen Experimental Station, Institute of Genetics and Experimental Plant Biology, Academy of Sciences, Republic of Uzbekistan. The studied genetic material also included the local and ancient wheat landraces and cultivars, such as, Kzyl-bugday, Ak-bugday (Grekkum), Tuya-tish, Pashmak, Khivit, Boboki, Muslimka, Kairaktash, Kzyl-shark, and Bezimyanniy, as well as the local wheat cultivar Surkhak collected from remote areas of Surkhandarya, Kashkadarya, and Jizzakh regions of the Republic of Uzbekistan.

A summary of the chemical reagents and equipment used in isolating grain gliadin proteins and polyacrylamide gel (PAAG) electrophoresis, methods for determining grain quality indicators, and statistical analysis follow the discussion. The obtained results for cluster analysis employed the computer program Statgraphics and statistical analysis used analysis of variance Stat Viev (www.statviev.com, SAS Institute Inc). The degree of dominance (hp) F_1 determination followed the formula of S. Wright, the correlation coefficient (r) and variation coefficient (V) of quantitative traits of F_2 plants identification were according to Dospekhov (1985), and their inheritance coefficient (h^2) utilized the formula of Allard (1956).

RESULTS AND DISCUSSION

Scientific research widely proceeds worldwide on the problems of conservation and rational use of plant genetic resources, which serve as the basis for developing breeding, sustainable agriculture, and food security. Landraces that have emerged from a combination of natural selection and breeding for productivity have shown tolerance to local stress factors, stable yields, and other grain qualities compared with existing commercial cultivars; therefore, they represent a valuable part of the gene pool and need inclusion in breeding during developing new commercial cultivars (Buronov and Xamroev, 2022).

During the research, organized expeditions went on in several regions of Uzbekistan to collect and study the local wheat landrace. Using the Global Positioning System (GPS) device, a special proforma earlier prepared, then filled out, reflected the locations and the collection request of wheat samples of various landraces. From the outlying zones of Surkhandarya, Kashkadarya, and Jizzakh regions of Uzbekistan came 31 specimens of ancient local wheat landraces, with their geographical location and phenological indicators (Table 1).

For the collection of the unique and ancient wheat genotypes, such as, Pashmak, Khivit, and Muslimka, as well as new wheat cultivars, i.e., Kzyl bugday, Grekkum, and Kairaktash, an expedition took place in the Districts of Sariosiyo, Altinsoy, and Uzun of the Surkhandarya region, Uzbekistan. Although these wheat genotypes during autumn sowings were similar to the previously studied landraces based on the number of spikelets and grains per spike, the length and the mass

Table 1. Geographic location and classification of local landraces of ancient wheat.

Latitude, longitude; height from sea level, m (N-north, E-east)	Cultivar	Sowing date	% amount of pure line and degree of mixing	Grain color	Plant height (cm)
Surkhandarya region, Boysun district, Duoba village (collected in 2010)					
3832121N, 6738181E;1391	Kzyl-bugday	March	Mixed up to 2% by other spikes	Red	120
3832480N,6736566E; 1544	Boboki	March	Pure line	Red	120
Kurgoncha village					
3837921N, 6741462E;1633	Kzyl-bugday	March	Mixed up to 5% by red spikes	Red	120
Gummatak village					
3835699N, 6737737E; 2136	Kzyl-bugday	March	Pure line	Red	130
3835986N, 6707070E;2174	Surkhak	March	Mixed up to 5% by oats	Red	130
3835057N, 6742538E;2143	Kalbugday	March	Pure line	Red	100
Pulhokim village					
3816484N, 6738905E;1050	Bukhor bobo	October	Pure line	Red	140
3816496N, 6738715E;1180	Kzyl-bugday	October	Mixed up to 5% by various spikes	White	120
3816600N, 6738760E;1190	Ak-bugday	October	Mixed up to 20% by red spikes	Red	100
3816645N, 6738750E;1090	Boysun Tura-1	October	Pure line	White	110
3816580N, 6738565E;1100	Boysun Tura-2	October	Pure line	Red	120
3816500N, 6738800E;1125	Kairaktash	March	Mixed up to 15% by red spikes	White	100
Kashkadarya region, Yakkabog district, Guldara village					
3878582N, 6681014E;1159	Ak-bugday	March	Pure line	White	120
3877369N, 6682451E;1270	Grekkum	March	Mixed up to 20% by Surkhak cultivar	White	120
Terakli village					
3875540N, 6681´783E;1634	Bezimyanniy	March	Mixed up to 20%	Red	100
3875934N, 6682´558E;1500	Korakiltik	November	Pure line	Red	120
Kamashi district, Kuga village					
3866376N, 6692´626E;2249	Ok bugday	March	Pure line	White	120
3863243E, 6694´461E;1988	Kzyl-shark	March	Pure line	Red	90
3864701N, 6693114E; 1731	Kzyl-bugday	March	Pure line	Red	120
Kiziltom village					
3861663N, 6693731E;1753	Tuyatish	March	Mixed up to 20% by red spikes	Red	120
3866376N, 6692626E;2249	Bezimyanniy	March	Mixed up to 20% by red spikes	Red	100
3865243N, 6690205E;2147	Muslimka	March	Mixed up to 20%	Red	100
3859266N, 6691480E;1317	Surkhak	March	Pure line	Red	130
Jizzakh region, Bakhmal district, Muzbulok village					
3971376N, 6812882E;1520	Grekkum	October	Pure line	White	115
Gallaorol district, Yonbosh village					
3970017N, 6819329E;1763	Surkhak	March	Mixed up to 20% by barley	Red	120
Surkhandarya region, Altinsoy district, (collected in 2013)					
3833086N, 6765667E;1301	Kzyl-bugday	October	Pure line	Red	105
3834088N, 6765678E;1361	Kzyl-shark	March	Mixed up to20 %	Red	110
Uzun district					
3861500N, 6758411E; 2008	Pashmak	October	Pure line	White	90
3860202N, 6756589E; 1650	Khivit	August	Pure line	White	90
3857685N, 6758622E;1558	Kzyl-bugday	March	Pure line	Red	110
3861500N, 6758521E; 1710	Surkhak	October	Mixed up to 15% by red spikes	Red wheat	110

of a spike and their average height was 130 cm for all the genotypes except Kairoktosh, and the beginning of the germination phase occurred later than 1 January, with the severe yellow rust damage also observed. The wheat cultivars, i.e., Pashmak, Khivit, and Kzyl bugday harvested in the Sariosiyo region, turned out as medium-sized and averaged at 40 g, having the average yield per square meter at 300 g. The wheat cultivars collected in Altinsoy and Uzun regions had relatively large grains, with an average 1000-grain weight of 44 g and a grain yield of more than 400 g per square meter. The grain yield was high for wheat cultivars adapted to rainfed lands.

When analyzing the distribution areas of the studied wheat cultivars, notably, more specimens of cultivar Kzyl-bugday grew in remote areas of the Surkhandarya region (located at an altitude of 1500–2500 masl), and the said cultivar was tall (up to 120–140 cm); the yield was up to 3.5 t ha^{-1} under optimal conditions, with reddish, large grains and the 1000-grain weight at 55–60 g. However, in Kashkadarya and Jizzakh regions, Uzbekistan, the wheat cultivar Ak-bugday was common, and in some places, it is also called Grekkum. These wheat landraces belong to the cultivar Grekkum, with white spikes, a whitish fluff, relatively large white grains, an average 1000-grain weight of 45–48 g, and a plant height of 95–100 cm. The description for wheat cultivars, viz., Boboki and Tuyatish, does not fit these two groups.

Sowing the collected 31 wheat cultivars from different regions under the same conditions had three replications. The data analysis based on the quantitative characteristics of all these wheat genotypes served as initial data. Under the field and laboratory conditions, the data recorded on various variables, including plant height, spike length, number of spikelets per spike, number of grains per spike, and grain mass per spike, went through statistical evaluation. Cluster analysis is a kind of classification used when several representations and standards are not available. It consists of combining objects into various groups (clusters) depending on their degree of similarity determined by the order of criteria based on the genotype's features and properties.

According to cluster analysis and the distribution of cultivars into various clusters, the Euclidean distance served as the interval of the genetic measure, with Ward's method utilized for the aggregation process through the Statgraphics computer program. The minimum number of clusters combining cultivars is four, and the maximum is seven. When analyzing the distribution into these groups, the 5-cluster analysis showed the most appropriate for determining the proximity of wheat cultivars based on economically valuable traits. As a result, the five clusters identified differed in a set of features and retained their properties in generations (Figure 1).

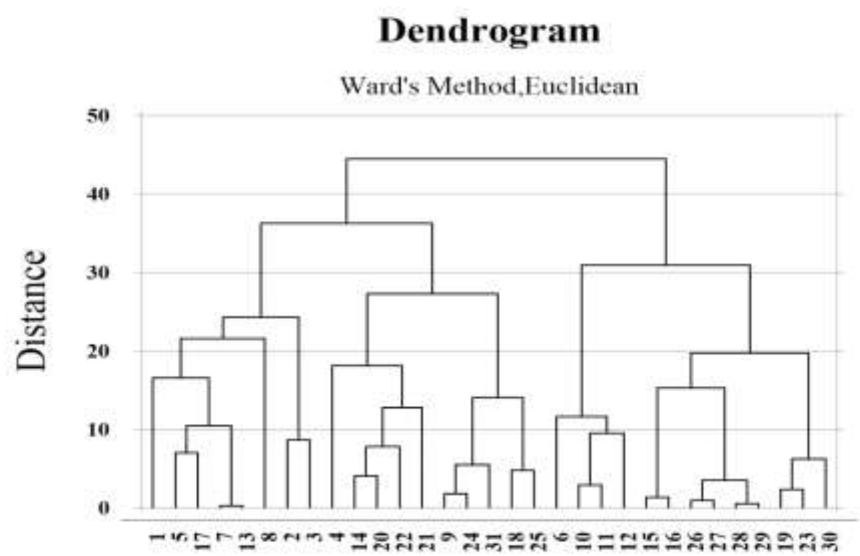

Figure 1. Diagram of distribution of ancient local cultivar samples into clusters by economically valuable traits.

Note: 1: Kzyl bugday (Kuga), 2: Kzyl bugday (Kurgancha), 3: Kzyl bugday (Gummatak), 4: Bukhor bobo, 5: Kzyl bugday (Duoba), 6: Unnamed (Kiziltom), 7: Ak bugday (Kuga), 8: Ak bugday (Kukbulok), 9: Tyuya-Tish (Kiziltom), 10: Surkhak (Duoba), 11: Unnamed (Kiziltepa), 12: Surkhak (Gummatak), 13: Graecum (Dangara), 14: Kalbugday (Kiziltom), 15: Kzyl shark (Kuga), 16: Korakiltik, 17: Graecum (Terali), 18: Boboki (Surkh., Boys), 19: Surkhak (Kiziltom), 20: Boysun Tura-1, 21: Kairaktash, 22: Ak bashak, 23: Kzyl bashak, 24: Boysun Tura-2, 25: Muslimka, 26: Kzyl bugday (Altinsoy), 27: Kzyl shark (Altinsoy), 28: Surkhak (Uzun), 29: Kzyl bugday (Uzun), 30: Pashmak (Uzun), 31: Khivit.

The data analysis indicated that the morphological characteristics of wheat cultivars sown on the territory of Uzbekistan since ancient times in small peasant farms, and cultivated on rainfed lands of the Republic, displayed the same grain color. Despite their differences in morphological characteristics, these cultivars were also similar in quantitative features and provided higher grain yield. Although, in this case, the inclusion of four samples of Kzyl-bugday in the first cluster previously listed in the catalog as four different samples, the study determined these genotypes were close based on economically valuable traits. Such cluster also included two white wheat samples and two more samples of Grekkum, with white grain and spike, which were tall plants prone to lodging. The cluster analysis showed their values and the possibility of using them in the breeding programs as potential genotypes with high rates for economically valuable parameters.

Correlation analysis revealed a weak positive relationship between the spike length and plant growth, the grain weight per spike and 1000-seed weight (r = 0.21, r = 0.20, 0.18, respectively), an average positive relationship between the grains per spike and grain weight per spike (r = 0.57, r = 0.62, respectively), and strong association with the number of spikelets (r = 0.83). Such vital economically valuable traits as plant height and 1000-seed weight of the studied ancient wheat cultivars have a weak relationship with other qualities. Additionally, strong positive relationships appeared between the spike length and spikelets per spike and the number and weight of spikelets.

In the fourth section, the polymorphism and inheritance of gliadin proteins in local and ancient wheat landraces, the variability and heritability of polymorphism had F_1 and F_2 populations analyzed for economically valuable traits and gliadin proteins. Comparative analysis of the electrophoretic spectra of 31 wheat genotypes isolated by morphological features revealed 27 ranges differing from each other, where the electrophoretic spectra of cultivar Bezostaya-1 served as a control. Analyses of 100 grains from each studied wheat cultivar showed that the electrophoretic spectra of 25 cultivars coincide, indicating homogeneity based on the gliadin proteins' continuum (Figure 2).

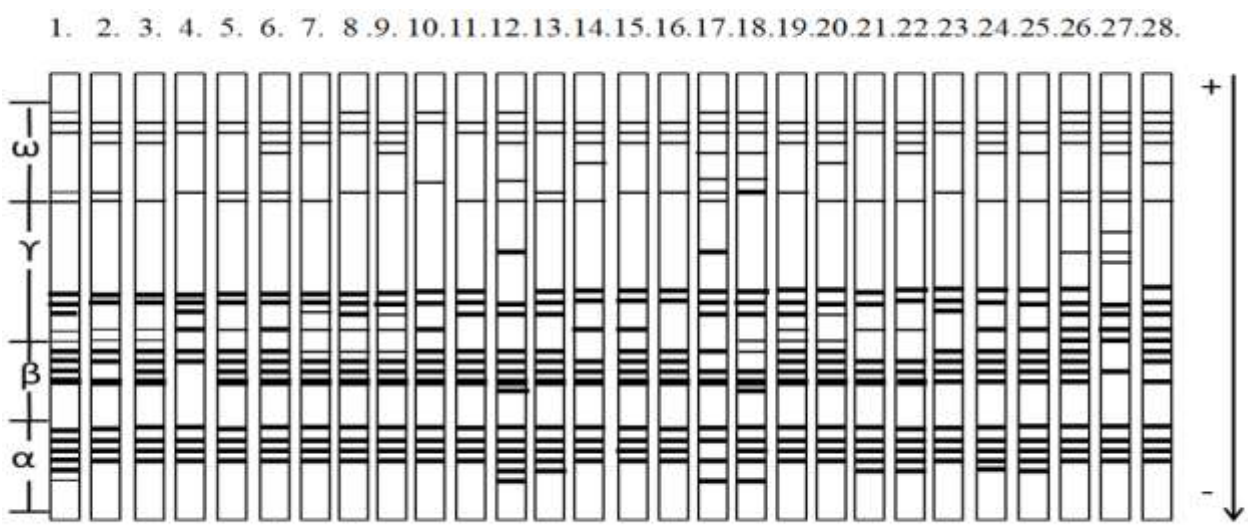

Figure 2. Polymorphism of gliadin proteins in ancient local cultivars of soft wheat in Uzbekistan.
Note: 1: Bezostaya-1 (marker), 2: Kzyl bugday (Kurgancha), 3: Kzyl bugday (Altinsoy), 4: Ak bugday (Kuga), 5: Graecum (Dangara), 6: Unnamed (Kiziltom), 7: Unnamed niy (Kiziltom), 8: Surkhak (Udamali), 9: Surkhak (Uzun), 10: Bukhor bobo, 11: Boysun-T-1, 12: Kairaktash, 13: Ak bashak, 14: Pashmak, 15: Surkhak (Bakhmal), 16: Surkhak (Bakhmal), 17: Boysun Tura-2, 18: Boysun Tura-2, 19: Tyuya-Tish, 20: Tyuya-Tish, 21: Khivit (Oltinsoy), 22: Khivit (Oltinsoy), 23: Boboki, 24: Boboki, 25: Boboki, 26: Kalbugday, 27: Kalbugday, 28: Kalbugday.

Moreover, the heritability and variability assessment of the hybrid populations led to isolating wheat samples with alternative traits for gliadin proteins. In hybrids Surkhak × Kzyl shark (hp = 0.2) and Ok boshok × Muslimka (hp = 0.8), the heritability of the trait spike length was in incomplete positive dominance, then, in hybrids, Tuyatish × Khivit (hp = 3.0) and Kzyl-bugday × Pashmak (hp = 2.5) determined complete dominance toward the high-indicative cultivar. In hybrid combinations, according to the degree of dominance for the trait number of spikelets, dominance, and positive over-dominance occurred with varying degrees (hp = 1.1, hp = 2.3, hp = 9.0), depending on the parental genotypes of the hybrids.

The hybrid Ak-bashok × Muslimka did not have a dominant state for this trait (hp = 0). In F_1 populations of the hybrid combinations Surkhak × Kzyl-shark (hp = 3.7) and Tuyatish × Khivit (hp = 4.5), studying the heritability of the trait grains per spike, the dominance of the high-indicative cultivar emerged, and in the populations of hybrid Ak-boshok × Muslimka (hp = -0.2), the said trait had a negative incomplete inheritance, indicating the effect of the maternal cytoplasm on this trait. According to the trait grain mass per spike, the notable highest values were for hybrids, i.e., Tuyatish × Khivit (2.5 ± 0.48) and Ak boshok × Muslimka (2.6 ± 0.65), and relatively low indicators were for the hybrid Kzyl bugday × Pashmak (1.8 ± 0.22). By analyzing the degree of dominance of traits in the studied wheat hybrids Surkhak × Kzyl shark (hp = 3.0) and Tuyatish × Khivit (hp = 5.0), the trait grain mass per spike showed predominant inheritance, and, in hybrids Ak-boshok × Muslimka, the dominance was none (hp = 0.0). In the hybrid Kzyl-bugday × Pashmak, the trait grain mass per spike's inheritance was according to the type of incomplete negative dominance (hp = -3.0).

Negative and positive transgressions occurred after analyzing the range of variability of the above trait in the F_2 populations. The state of unfavorable error was illustrative in the division of plants with a smaller number of grains in one spike compared with parental forms with a shift to class 1 in the F_2 population, viz., Ak-boshok × Muslimka and Kzyl-bugday × Pashmak. In these hybrids, plants formed the grains in the intermediate class ranging from 30.0 to 36.9 pieces accounting for 48.0%–36.0%. The increase in the range of variability and selecting genotypes with a higher number of grains in F_2 populations were expressive from a shift to the right side of classes 4–5 relative to the parental cultivars. It also indicated that the grains per spike were in the range of 0.96–0.98, which is a high indicator of the heritability for the said trait in F_2 populations. Segregation of high-scoring genotypes transpired in the F_2 generation.

In F_2 populations, the low range of variability correlates with the isolation of plants lower than the parental forms. According to the trait grain mass per spike, all the studied plants showed a state of left-sided transgression. Negative transgressive hybrids showed a shift towards 2–3 classes. In the crosses Surkhak × Kizil shark, the number of plants with a grain weight of 1.2–1.3 g was 28.0%, and in hybrids Tuyatish × Khivit, Ak boshok × Muslimka, and Kizil bugday × Pashmak, with a grain weight of 1.4–1.5 g, at 38.0%, 36.0%, and 41.0%, respectively.

Analysis of the inheritance and variability of the electrophoretic composition of gliadin proteins of parental genotypes of ancient local soft wheat of Uzbekistan and their F_1 and F_2 populations also materialized. Factually, determining the electrophoretic spectrum of grain storage proteins gliadins and glutenins is genetic; thus, it does not depend on the growing and environmental conditions. Gliadins, formed as a monomeric chain, make up 50% of grain proteins from electrophoretic mobility and consist of four different forms (α-gliadin, β-gliadin, γ-gliadin, and ω-gliadin) (Sozinov, 1985; Baboev *et al*., 2013).

First, separating wheat cultivars selected as parental forms, they ran into hybridization with other cultivars that differ in the electrophoretic composition of gliadin proteins in at least two zones. According to the electrophoretic spectral formula of gliadin proteins of parental forms, the immense number of components was in the cultivars, i.e., Khivit (16) and Kzyl shark (16), and

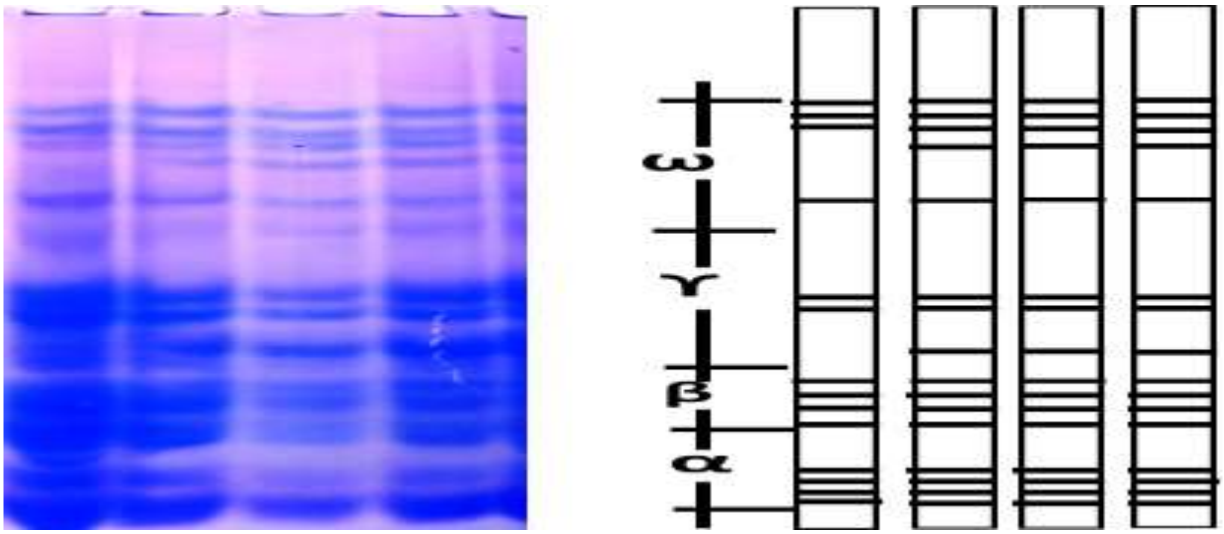

Figure 3. Electropherograms of cultivar Surkhak (1), F_1 hybrid seeds (2, 3), and cultivar Kzyl shark (4).

placing the smallest number of sections was in the cultivar Surkhak (14). Noticeably, the studied components of gliadin proteins in F_1 populations attained an inheritance in the heterozygous state. Based on the formula of the electrophoretic spectrum, the cultivar Surkhak consists of 14 components, and it differs from the cultivar Kzyl-shark in the absence of the γ2 and ω5 units in the γ and ω zones (Figure 3).

The electrophoretic formula of gliadin proteins, forming 17 components according to the process of the electrophoretic spectrum in F_1 populations, had the following form, i.e., α4567, β2345, γ234, and ω25678. By analyzing the electrophoretic technique of the heredity and variability of gliadin proteins in F_2 populations obtained from ancient local wheat cultivars of Uzbekistan, an observed separation of four hybrids Kzyl bugday × Pashmak, Tuyatish × Khivit, Ak boshok × Muslimka, and Surkhak × Kzyl-shark had a ratio of 1:2:1 concerning the electrophoretic composition of the parental populations. The F_2 hybrids Tuyatish-Khivit also showed the inheritance of gliadin proteins in a proportion of 1:2:1. Meanwhile, 34 plant grains had the electrophoretic composition of the parental cultivar Tuyatish, and 51 plant grains belonged to the heterozygous electrophoretic composition, with 23 plant grains similar to the paternal parent cultivar Khivit (X2 = 3.25, P > 0.05) (Figure 4).

The study of the yield and quality traits of pure lines obtained by selecting the storage proteins of wheat landraces and cultivars of Uzbekistan by the electrophoretic composition met scrutiny, with the analysis based on economically valuable traits of the wheat cultivar Kairaktash conducted. Adapted to the rainfed conditions of the Republic, the cultivar Kairaktash's release had the process of individual selection from ancient local cultivars of wheat. The various quantitative traits for the wheat cultivar comprised plant height (80–85 cm), sharp awny spike, white grains, gluten (35.6%), index deformation gluten (IDG) (74.6), vegetation period (213–217 days), sowing seed rate (100–150 kg ha^{-1}), and the sowing time in autumn (October 15–20) and spring (March 5–10).

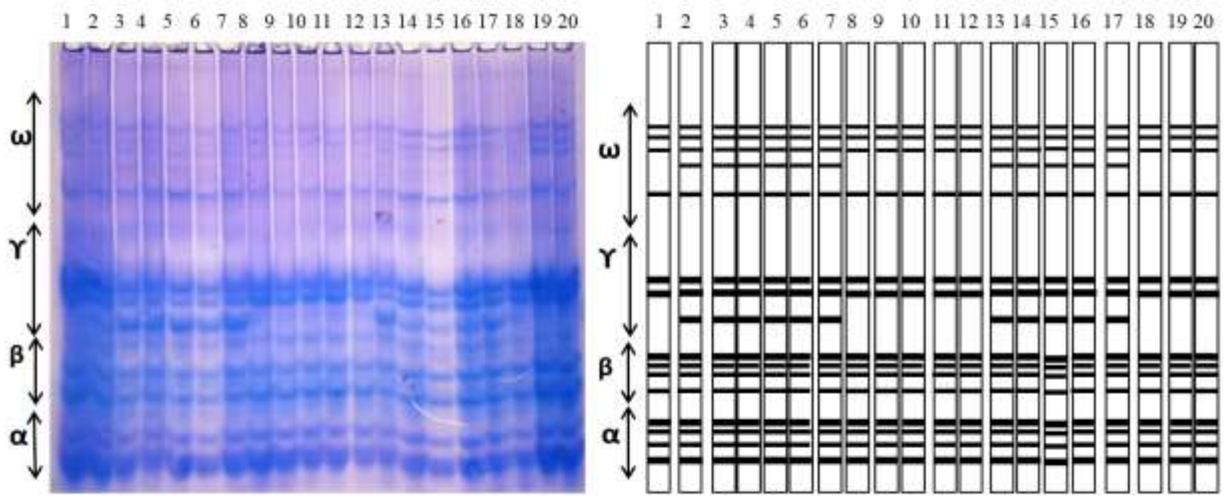

Figure 4. Electropherograms of gliadin in parental cultivars Tuyatish (1), Khivit (2), and F_2 hybrids.

CONCLUSIONS

In a cluster analysis and according to quantitative traits, local wheat cultivars' grouping consisted of five clusters and a compiled dendrogram. Based on the dendrogram, it determined that the morphological features of ancient local wheat cultivars, though having the same color of grain, can differ yet indicate closely related according to quantitative traits that ensure the grain yield. The economic attributes, such as, plant height and 1000-seed weight, revealed a weak correlation but strong positive correlations appeared between the spike length and spikelets per spike and the number and grain weight per spike. By studying 31 ancient and local wheat cultivars by electrophoretic spectra of gliadin, 25 were homogeneous for this trait, while six genotypes were heterogeneous. Based on index deformation gluten (IDG) indicators and according to quantitative traits and the amount of gluten, a drought-resistant soft wheat cultivar 'Kairaktash' was released, adapted to rainfed conditions, and introduced into production.

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